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Thursday, August 30, 2007

Money and the problem of cooperation

From "Shelling Out: The Origins of Money":

> Evolutionary psychology starts with a key mathematical discovery of John Maynard Smith [D89]. Using models of populations of co-evolving genes, from the well-developed area of population genetics, Smith posited genes that can code for strategies, good or bad, used in simple strategic problems (the "games" of game theory). Smith proved that these genes, competing to be propagated into future generations, will evolve strategies that are Nash equilibria to the strategic problems presented by the competition. These games include the prisoner's dilemma, a prototypical problem of cooperation, and hawk/dove, a prototypical problem of aggression and its mitigation.
>
> Critical to Smith's theory is that these strategic games, while played out between phenotypes proximately, are in fact games between genes at the ultimate level -- the level of competition to be propagated. The genes -- not necessarily the individuals -- influence behavior as if they were boundedly rational (coding for strategies as optimal as possible, within the limits of what phenotypes can express given the biological raw materials and previous evolutionary history) and "selfish" (to use Richard Dawkins' metaphor). Genetic influences on behavior are adaptations to the social problems presented by genes competing through their phenotypes. Smith called these evolved Nash equilibria *evolutionary stable strategies.*.
>
> The "epicycles" built on top of the earlier individual selection theory, such as sexual selection and kin selection, disappear into this more general model which, in a Copernican manner, puts the genes rather than individuals at the center of the theory. Thus Dawkins' metaphorical and often misunderstood phrase, "selfish gene", to describe Smith's theory.
>
> Few other species cooperate on the order of even Paleolithic humans. In some cases -- brood care, the colonies of ants, termites, and bees, and so forth, animals cooperate because they are kin -- because they can help copies of their "selfish genes" found in their kin. In some highly constrained cases, there is also ongoing cooperation between non-kin, which evolutionary psychologists call reciprocal altruism. As Dawkins describes it [D89], unless an exchange of favors is simultaneous (and sometimes even then), one party or the other can cheat. And they usually do. This is the typical result of a game theorists call the Prisoner's Dilemna -- if both parties cooperated, both would be better off, but if one cheats, he gains at the expense of the sucker. In a population of cheaters and suckers, the cheaters always win. However, sometimes animals come to cooperate through repeated interactions and a strategy called Tit-for-Tat: start cooperating

Pages

- Home

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and keep cooperating until the other party cheats -- then defect yourself. This threat of retalation motivates continued cooperation.

The situations where such cooperation in fact occurs in the animal world are highly constrained. The main constraint is that such cooperation is restricted to relationships where at least one of the participants is more or less forced to be in the proximity of the other. The most common case is when parasites, and hosts whose bodies they share, evolve into symbiotes. If the interests of the parasite and the host coincide, so that both working together would be more fit than either on their own, (i.e. the parasite is also providing some benefit to the host), then, if they can play a successful game of Tit-for-Tat, they will evolve into symbiosis -- a state where their interests, and especially the exit mechanism of genes from one generation to the next, coincides. They become as a single organism. However, there is much more than cooperation going on here -- there is also exploitation. They occur simultaneously. The situation is ananalogous to an institution humans would develop -- tribute -- which we will analyze below.

Some very special instances occur that do not involve parasite and host sharing the same body and evolving into symbiotes. Rather, they involve non-kin animals and highly constrained territory. A prominent example Dawkins describes are cleaner fish. These fish swim in and out of the mouths of their hosts, eating the bacteria there, benefiting the host fish. The host fish could cheat -- it could wait for the cleaner to finish its job, then eat it. But they don't. Since they are both mobile, they are both potentially free to leave the relationship. However, the cleaner fish have evolved a very strong sense of individual territoriality, and have stripes and dances that are difficult to spoof -- much like a difficult to forge brand logo. So the host fish know where to go to get cleaned -- and they know that if they cheat, they will have to start over again with a new distrustful cleaner fish. The entrance costs, and thus the exit costs, of the relationship are high, so that it works out without cheating. Besides, the cleaner fish are tiny, so the benefit of eating them is not large compared to the benefit of a small number of, or even one, cleaning.

One of the most pertinent examples.is the vampire bat. As their name suggests, they suck the blood of prey mammals. The interesting thing is that, on a good night, they bring back a surplus; on a bad night, nothing. Their dark business is highly unpredictable. As a result, the lucky (or skilled) bats often share blood with the less lucky (or skilled) bats in their cave. They vomit up the blood and the grateful recipient eats it.

The vast majority of these recipients are kin. Out of 110 such regurgitations witnessed by the strong-stomached biologist G.S. Wilkinson, 77 were cases of mothers feeding their children, and most of the other cases also involved genetic kin. There were, however, a small number that could not be explained by kin altruism. To demonstrate these were cases of reciprocal altruism, Wilkinson combined the populations of bats from two different groups. Bats, with very rare exception, only fed old friends from their original group. [D89]. Such cooperation requires building a long-term relationship, where partners interact often, recognize each other, and keep track of each other's behavior. The bat cave helps constrain the bats into long-term relationships where such bonds can form.

We will see that some humans, too, chose highly risky and discontinuous prey items, and shared the resulting surpluses with non-kin. Indeed, they accomplished this to a far greater extent than the vampire bat. How they did so is the main subject of our essay. Dawkins suggests, "money is a formal token of delayed reciprocal altruism", but then pursues this fascinating idea no further. We will.

Among small human groups, public reputation can supercede retaliation by a single individual to motivate cooperation in delayed reciprocation. However, reputational beliefs can suffer from two major kinds of errors -- errors of about which person did what, and errors in appraising the value or damages caused by that act.

The need to remember faces and favors is a major cognitive hurdle, but one that most humans find relatively easy to

Blog Archive

- ► 2018 (1)
- ► 2017 (3)
- ► 2016 (4)
- ► 2015 (3)
- ► 2014 (3)
- ► 2013 (3)
- ► 2012 (8)
- ► 2011 (12)
- ► 2010 (9)
- ► 2009 (29)
- ► 2008 (55)
- ▼ 2007 (47)
  - ► December (1)
  - ► October (2)
  - ► September (8)
  - ▼ August (10)
    - Money and the problem of cooperation
    - Why the industrial revolution?
    - Mutually private computation
    - Blind signatures
    - Personal jurisdiction before sovereignty
    - Smart contracts watch
    - Exit and freedom
    - Our new omniscient savior
    - Ten ways to make a political difference
    - Government for profit
  - ► July (4)
  - ► June (4)
  - ► May (8)
  - ► April (1)
  - ► March (2)
  - ► February (4)
  - ► January (3)

overcome. Recognizing faces is easy, but remembering that a favor took place when such memory needs to be recalled can be harder. Remembering the specifics about a favor that gave it a certain value to the favored is harder still. Avoiding disputes and misunderstandings can be improbable or prohibitively difficult.

The appraisal or value measurement problem is very broad. For humans it comes into play in any system of exchange -- reciprocation of favors, barter, money, credit, employment, or purchase in a market. It is important in extortion, taxation, tribute, and the setting of judicial penalties. It is even important in reciprocal altruism in animals. Consider monkeys exchanging favors -- say pieces of fruit for back scratches. Mutual grooming can remove ticks and fleas that an individual can't see or reach. But just how much grooming versus how many pieces of fruit constitutes a reciprocation that both sides will consider to be "fair", or in other words not a defection? Is twenty minutes of backscratching worth one piece of fruit or two? And how big a piece?

Even the simple case of trading blood for blood is more complicated then it seems. Just how do the bats estimate the value of blood they have received? Do they estimate the value of a favor by weight, by bulk, by taste, by its ability to satiate hunger, or other variables? Just the same, measurement complications arise even in the simple monkey exchange of "you scratch my back and I'll scratch yours".

For the vast majority of potential exchanges, the measurement problem is intractible for animals. Even more than the easier problem of remembering faces and matching them to favors, the ability of both parties to agree with sufficient accuracy on an estimate of the value of a favor in the first place is probably the main barrier to reciprocal altruism among animals.

Just the stone tool-kit of even early Paleolithic man that has survived for us to find was in some ways too complicated for brains of our size. Keeping track of favors involving them -- who manufactured what quality of tool for whom, and therefore who owed whom what, and so on -- would have been too difficult outside the boundaries of the clan. Add onto that, quite likely, a large variety of organic objects, ephemeral services (such as grooming), and so on that have not survived. After even a small fraction of these goods had been transferred and services performed our brains, as inflated as they are, could not possibly keep track of who owed what to whom. Today we often write these things down -- but Paleolithic man had no writing. If cooperation occured between clans and even tribes, as the archaeological record indicates in fact occured, the problem gets far worse still, since hunter-gatherer tribes were usually highly antagonistic and mutually distrustful.

If clams can be money, furs can be money, gold can be money, and so on -- if money is not just coins or notes issued by a government under legal tender laws, but rather can be wide variety of objects -- then just what is money anyway? And why did humans, often living on the brink of starvation, spend so much time making and enjoying those necklaces when they could have been dong more hunting and gathering? Nineteenth century economist Carl Menger [M1892] first described how money evolves naturally and inevitably from a sufficient volume of commodity barter. In modern economic terms the story is similar to Menger's.

Barter requires a coincidence of interests. Alice grows some pecans and wants some apples; Bob grows apples and want some pecans. They just happen to have their orchards near each other, and Alice just happens to trust Bob enough to wait between pecan harvest time and apple harvest time. Assuming all these conditions are met, barter works pretty well. But if Alice was growing oranges, even if Bob wanted oranges as well as pecans, they'd be out of luck -- oranges and apples don 't both grow well in the same climate. If Alice and Bob didn't trust each other, and couldn't find a third party to be a middleman [L94] or enforce a contract, they'd also be out of luck.

Further complications could arise. Alice and Bob can't fully articulate a promise to sell pecans or apples in the future,

► 2006 (130)
► 2005 (44)

because, among other possibilities, Alice could keep the best pecans to herself (and Bob the best apples), giving the other the dregs. Comparing the qualities as well as the quantities of two different kinds of goods is all the more difficult when the state of one of the goods is only a memory. Furthermore, neither can anticipate events such as a bad harvest. These complications greatly add to the problem of Alice and Bob deciding whether separated reciprocal altruism has truly been reciprocal. These kinds of complications increase the greater the time interval and uncertainty between the original transaction and the reciprocation.

A related problem is that, as engineers would say, barter "doesn't scale". Barter works well at small volumes but becomes increasingly costly at large volumes, until it becomes too costly to be worth the effort. If there are **n** goods and services to be traded, a barter market requires **n^2** prices. Five products would require twenty-five prices, which is not too bad, but 500 products would require 250,000 prices, which is far beyond what is practical for one person to keep track of. With money, there are only **n** prices -- 500 products, 500 prices. Money for this purpose can work either as a medium of exchange or simply as a standard of value -- as long as the number of money prices themselves do not grow too large to memorize or change too often. (The latter problem, along with an implicit insurance "contract", along with the lack of a competitive market may explain why prices were often set by long-evolved custom rather than proximate negotiation).

Barter requires, in other words, coincidences of supply or skills, preferences, time, and low transaction costs. Its cost increases far faster than the growth in the number of goods traded. Barter certainly works much better than no trade at all, and has been widely practiced. But it is quite limited compared to trade with money.

Primitive money existed long before large scale trade networks. Money had an even earlier and more important use. Money greatly improved the workings of even small barter networks by greatly reducing the need for credit. Simultaneous coincidence of preference was far rarer than coincidences across long spans of time. With money Alice could gather for Bob during the ripening of the blueberries this month, and Bob hunt for Alice during the migration of the mammoth herds six months later, without either having to keep track of who owed who, or trust the other's memory or honesty. A mother's much greater investment in child rearing could be secured by gifts of unforgeable valuables. Money converts the division of labor problem from a prisoner's dilemma into a simple swap.

The proto-money used by many hunter-gatherer tribes looks very different from modern money, now serves a different role in our modern culture, and had a function probably limited to small trade networks and other local institutions discussed below. I will thus call such money *collectibles* instead of money proper. The terms used in the anthropological literature for such objects are usually either "money", defined more broadly than just government printed notes and coins but more narrowly than we will use "collectible" in this essay, or the vague "valuable", which sometimes refers to items that are not collectibles in the sense of this essay.

Reasons for choosing the term collectible over other possible names for proto-money will become apparent. Collectibles had very specific attributes. They were not merely symbolic. While the concrete objects and attributes valued as collectible could vary between cultures, they were far from arbitrary. The primary and ultimate evolutionary function of collectibles was as a medium for storing and transfering wealth. Some kinds of collectibles, such as wampum, could be quite functional as money as we moderns know it, where the economic and social conditions encouraged trade. I will occasionally use the terms "proto-money" and "primitive money" interchangeably with "collectible" when discussing pre-coinage media of wealth transfer.

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